


EVALUATION OF RECENT TRENDS IN WATER QUALITY IN THE ELBOW RIVER UPSTREAM FROM GLENMORE RESERVOIR

Prepared by:

Al Sosiak, M.Sc.
Limnologist

Water Sciences Branch
Water Management Division
Natural Resources Service

July, 1999



Digitized by the Internet Archive
in 2016

<https://archive.org/details/evaluationofrece00sosi>

EXECUTIVE SUMMARY

Water Sciences Branch, Alberta Environment (AENV) was asked to determine if any significant changes had occurred in the water quality of the Elbow River upstream from Glenmore Reservoir, since the previous survey by the Alberta government (Beers and Sosiak 1993). All the available water quality data for the Glenmore Reservoir and the upper Elbow River were compiled and evaluated. Those variables with a sufficient number of samples were then tested statistically to determine whether significant changes in concentration had occurred over time.

This analysis found significant increases in total dissolved phosphorus, fecal coliforms, total coliforms and turbidity in the upper Elbow River at Highway 8 (Twin Bridges) since the previous basin-wide survey. Furthermore, water quality guidelines for the protection of aquatic life, irrigation and recreation were exceeded at the Twin Bridges site. Over the same time period, there was a significant decrease in total nitrogen and no significant change in the other variables that were tested for trends (flow, total phosphorus, chlorophyll *a*, total inorganic nitrogen, and total and dissolved organic carbon). Ongoing monitoring is necessary to confirm these trends.

There are insufficient data to determine the cause of increasing trends in the identified variables. Basin-wide sampling at locations sampled in 1988-90 should be repeated. Automated sampling of the Elbow River basin between Bragg Creek and Glenmore Reservoir was initiated in spring 1999 to enhance the existing database.

No evidence of adverse impacts on the Glenmore Reservoir was found.

ACKNOWLEDGEMENTS

I thank all technical and professional staff of Alberta Environment who have assisted in this analysis. Bridgette Halbig, Water Sciences Branch, AENV assisted in data compilation and report preparation. Jamie Dixon of the Waterworks Division provided water quality data from the City of Calgary. David Trew reviewed the manuscript and provided useful comments.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
ACKNOWLEDGEMENTS	ii
LIST OF TABLES	iv
LIST OF FIGURES	iv
 1.0 INTRODUCTION	 1
 2.0 ANALYTICAL METHODS	 1
 3.0 RESULTS AND DISCUSSION	 2
 4.0 CONCLUSIONS AND RECOMMENDATIONS	 3
 5.0 LITERATURE CITED	 4

LIST OF TABLES

- Table 1. Significant monotonic trends (slopes in bold font) in biological and chemical variables in the Elbow River at Twin Bridges.
- Table 2. Number of samples that exceeded water quality guidelines each year in the Elbow River at Twin Bridges, 1979-97.

LIST OF FIGURES

- Figure 1. Elbow River water quality sampling site locations.
- Figure 2. Dissolved phosphorus at Twin Bridges, 1988-97.
- Figure 3. Seasonal variation in dissolved phosphorus.
- Figure 4. Fecal coliforms at Twin Bridges, 1979-97.
- Figure 5. Seasonal variation in fecal coliforms.
- Figure 6. Total coliforms at Twin Bridges, 1979-97.
- Figure 7. Turbidity at Twin Bridges, 1979-97 (JTU: 79-80; NTU: 88-97).

1.0 INTRODUCTION

As part of the Bow Basin Plan, Water Sciences Branch, Alberta Environment (AENV) was asked to determine whether any significant changes had occurred in the water quality of the Elbow River upstream from Glenmore Reservoir, since the previous survey by the Alberta government in 1988-90 (Beers and Sosiak 1993). Beers and Sosiak (1993) found that water quality was generally good upstream from Calgary, except for increases in particulate matter during peak flow.

To determine whether water quality in the upper Elbow River has changed since 1988-90, all the available water quality data for the Glenmore Reservoir and the upper Elbow River were first compiled and evaluated. Variables with a sufficient number of samples were then compared to water quality guidelines and tested for monotonic trends, which are defined as gradual changes in concentration in one direction (i.e., over time).

2.0 ANALYTICAL METHODS

Water quality data collected by AENV and the City of Calgary at Twin Bridges (Highway 8 Bridge), Sarcee Bridge (in the former military range) (Figure 1) and lake composite data from the Glenmore Reservoir were compiled and evaluated statistically. Few samples were available from the Sarcee Bridge site after 1990. Accordingly, data from the Twin Bridges site were selected for trend analysis. Only data from the Glenmore Reservoir near the Weaselhead area were evaluated, as this location would be most influenced by inflow from the Elbow River.

In consultation with J. Dixon (Waterworks Division), all phosphorus data collected by the City of Calgary from the river sites in 1990-92 were deleted, due to concerns about the accuracy of these measurements. Ongoing duplicate analyses of split samples from Twin Bridges (1994-97) by Maxxam Analytics for AENV has generally confirmed that other data from the City of Calgary laboratory are of acceptable quality. Data from AENV (1979, 1988-90) and the City of Calgary (1982-83, 1989-97) were then merged, and paired with flow measurements from the Sarcee Bridge flow gauging station. To permit numerical analysis, values less than detection limits were replaced by values equivalent to one-half of the detection limit.

Variables with at least four years of data during 1979-97 were then compared to the Canadian and Alberta water quality guidelines (CCME 1999, AEP 1994) and tested for trends.

Variables were first tested with the Kruskal-Wallis test for seasonality. Variables exhibiting significant seasonality were tested for monotonic trends using the Seasonal Kendall Test, with (SKWC) or without (SKWOC) correction for significant serial correlation, using procedures in the computer program WQHYDRO (Aroner 1994). Data that did not display significant seasonal variation were tested for monotonic trends using the Mann-Kendall test. As recommended by Ward et al. (1990), a 0.10 level of statistical significance was used to assess the results of all tests.

3.0 RESULTS AND DISCUSSION

Significant trends were detected in four of the eight water quality variables tested for trends at the Elbow River at Twin Bridges. Significant increasing trends in the concentration of dissolved phosphorus, turbidity, fecal coliforms and total coliforms were detected at this site during at least part of the time period 1979-97 (Table 1). Except for dissolved phosphorus, for which there is no guideline, these variables also exceeded water quality guidelines for the protection of aquatic life, irrigation or recreation more often in recent years (Table 2, Figures 4, 6, 7). Although no significant trend in total phosphorus was detected, this variable has also exceeded the Alberta water quality guideline more frequently in recent years (Table 2).

These results suggest appreciable increases in these variables in the watershed upstream from Highway 8. In the nine years since the last basin-wide survey in 1988-90, the slope estimates for these trends indicate a 1.89 $\mu\text{g/L}$ increase in dissolved phosphorus (0.21 $\mu\text{g/L}$ per year) and 4.52 cells/100 mL increase in fecal coliforms. There were insufficient data to determine whether the phosphorus trend has resulted in an increase in periphytic algal biomass in the Elbow River.

No significant trends were detected in flow, total or dissolved organic carbon, total phosphorus or total inorganic nitrogen. There were insufficient data to test any of the other variables. Since there was no flow trend detected during 1979-97, there was no evidence that changing flow in the Elbow River caused any of the trends that were detected.

Although phosphorus levels have increased in the Elbow River, there is no evidence to date of increases in algal biomass, phosphorus or other variables in Glenmore Reservoir. Total nitrogen decreased in the reservoir composite samples collected near Weaselhead, and no trends were detected in the other variables that were tested (Table 1). This location appeared to provide the longest consistent record for the reservoir, and would most likely be affected by increased river

loading. However, insufficient turbidity and coliform data were available for testing from this reservoir site.

There are insufficient data to determine the cause of increasing trends in some constituents. However, potential sources are suggested by the significant seasonal variation that occurred in each constituent. Levels of dissolved phosphorus at Twin Bridges peaked in March (Figure 3), when snowmelt typically occurs in the foothills. This could reflect high nutrient loadings in spring runoff from livestock wintering areas, as documented elsewhere in Alberta. Fecal coliform levels at Twin Bridges peaked in May (Figure 5), before peak flows in June from mountain snow melt. This pattern could be caused by seepage from septic fields, following shallow ground water recharge. Turbidity levels at Twin Bridges peaked in June, which suggests channel erosion during high flows.

Ongoing sampling of the Twin Bridges site, with consistent sampling and analytical methods, is required to confirm the trends detected in this analysis. To determine the sources of these constituents will require more intensive sampling. Automated sampling of the Elbow River between Bragg Creek and the Glenmore Reservoir was initiated in spring 1999 to enhance the existing data base. Synoptic surveys of mainstem sites and all major tributaries during spring runoff could be used in the future to identify specific loading sources.

4.0 CONCLUSIONS AND RECOMMENDATIONS

1. Levels of dissolved phosphorus, fecal coliforms, total coliforms and turbidity have increased in the Elbow River upstream from Glenmore Reservoir since the previous basin-wide survey. However, this analysis found no evidence of adverse impacts on the Glenmore Reservoir. Ongoing monitoring is necessary to confirm these trends.
2. There are insufficient data to determine the cause of increasing trends in these variables. Basin wide sampling at locations sampled in 1988-90 should be repeated. Automated sampling of the Elbow River basin between Bragg Creek and Glenmore Reservoir was initiated in spring 1999 to enhance the existing data base.

5.0 LITERATURE CITED

- Alberta Environmental Protection. 1994. Alberta Ambient Surface Water Quality Interim Guidelines. Environmental Protection and Enhancement Act.
- Aroner, E.R. 1994. WQHYDRO. Water quality/hydrology/graphics/analysis system. User's Manual. P.O. Box 18149, Portland, OR.
- Beers, C. and A. Sosiak. 1993. Water quality of the Elbow River. Environmental Quality Monitoring Branch, Environmental Assessment Division, Alberta Environmental Protection.
- CCME. 1999. Canadian Water Quality Guidelines. Task force on water quality guidelines of the Canadian Council of Ministers of the Environment.
- Ward, R.C., J.C. Loftis, H.P. DeLong, H.F. Bell. 1990. Ground water quality data analysis protocol. Journal of the Water Pollution Control Federation. 1938-1945.

Table 1. Significant monotonic trends (slopes in bold font) in biological and chemical variables in the Elbow River at Twin Bridges. Sampling periods for each variable are in parentheses.

Sen Slope (Units/Year) for Significant Trends (Seasonal Kendal Tau Test)					
SITES	VARIABLES				
	Flow m ³ /s	Turbidity JTU/NTU	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Total Nitrogen µg/L
Elbow R. at Twin Bridges	NS ^a (79-97)	+0.054 (79-97)	NS (82-97)	+0.21 (88-97)	-16.84 (82-97)
	Total Inorganic Nitrogen mg/L	Total Organic Carbon mg/L	Dissolved Organic Carbon mg/L	Fecal Coliforms No./100 mL	Total Coliforms No./100 mL
Elbow R. at Twin Bridges	NS (82-97)	NS (79-97)	NS (83-97)	+0.502 (79-97)	+4.444 (79-97)
	Total Phosphorus µg/L	Total Dissolved Phosphorus µg/L	Total Nitrogen µg/L	Total Inorganic Nitrogen µg/L	Phytoplankton Chlorophyll <i>a</i> µg/L
Glenmore Reservoir near Weaselhead	NS (1982-97)	NS (1993-97)	-8.10 (82-97)	NS (82-97)	NS (1982-97)

^a NS: Not Statistically Significant

Table 2. Number of samples that exceeded water quality guidelines each year in the Elbow River at Twin Bridges, 1979-97. None of the nitrite^h, nitrite+nitrateⁱ or ammonia^j samples exceeded water quality guidelines.

	Total Phosphorus		Total Nitrogen		Turbidity			Total Coliforms		Fecal Coliforms		
	n ^k	no. >GL	n	no. >GL	n	no. >GL	no. >GL	n	no. >GL	n	no. >GL	no. >GL
Guideline:	0.05 mg/L ^a		1.0 mg/L ^b		22 NTU ^c 25 NTU ^d			1000 cells/100 mL ^e		100 cells/100 mL ^f 400 cells/100 mL ^g		
1979	24	1	0	0	23	0	0	23	0	23	0	0
1982	5	0	5	0	0	0	0	5	0	5	0	0
1983	8	1	10	0	0	0	0	10	0	10	1	0
1988	11	0	0	0	12	1	1	12	0	12	0	0
1989	4	0	0	0	11	0	0	21	0	22	0	0
1990	2	1	0	0	6	1	1	14	0	10	0	0
1991	0	0	0	0	11	2	2	15	0	14	0	0
1992	0	0	1	0	11	2	2	35	0	33	1	0
1993	7	3	0	0	0	0	0	0	0	0	0	0
1994	37	1	8	0	10	0	0	0	0	34	1	0
1995	51	6	12	1	13	3	3	0	0	38	3	0
1996	49	3	13	0	12	0	0	32	1	44	1	0
1997	41	1	11	0	13	1	1	44	4	44	1	1

^a Alberta Ambient Surface Water Quality Interim Guideline (1994)

^b Alberta Ambient Surface Water Quality Interim Guideline (1994)

^c CCME (1992, cited in CCME 1999) guideline for recreational water quality and aesthetics: increase of 5 NTU over background, here defined as the maximum concentration in 1979 (17 mg/L)

^d CCME (1999) guideline for the protection of aquatic life: increase of 8 NTU over background, here defined as the maximum concentration in 1979 (17 mg/L)

^e CCME (1987, cited in CCME 1999) guideline for the protection of agricultural uses (irrigation)

^f CCME (1987) guideline for the protection of agricultural uses (irrigation)

^g CCME (1987) guideline for recreational water quality and aesthetics: resample when any sample >400 cells/100 mL

^h CCME (1987) guideline for the protection of aquatic life (0.06 mg/L nitrite as N)

ⁱ CCME (1987) guideline for drinking water quality (10.0 mg/L nitrite+nitrate as N)

^j most stringent CCME (1987) guideline for the protection of aquatic life for the range of pH and temperature likely to occur at this site (1.33 mg/L total ammonia)

^k sample size

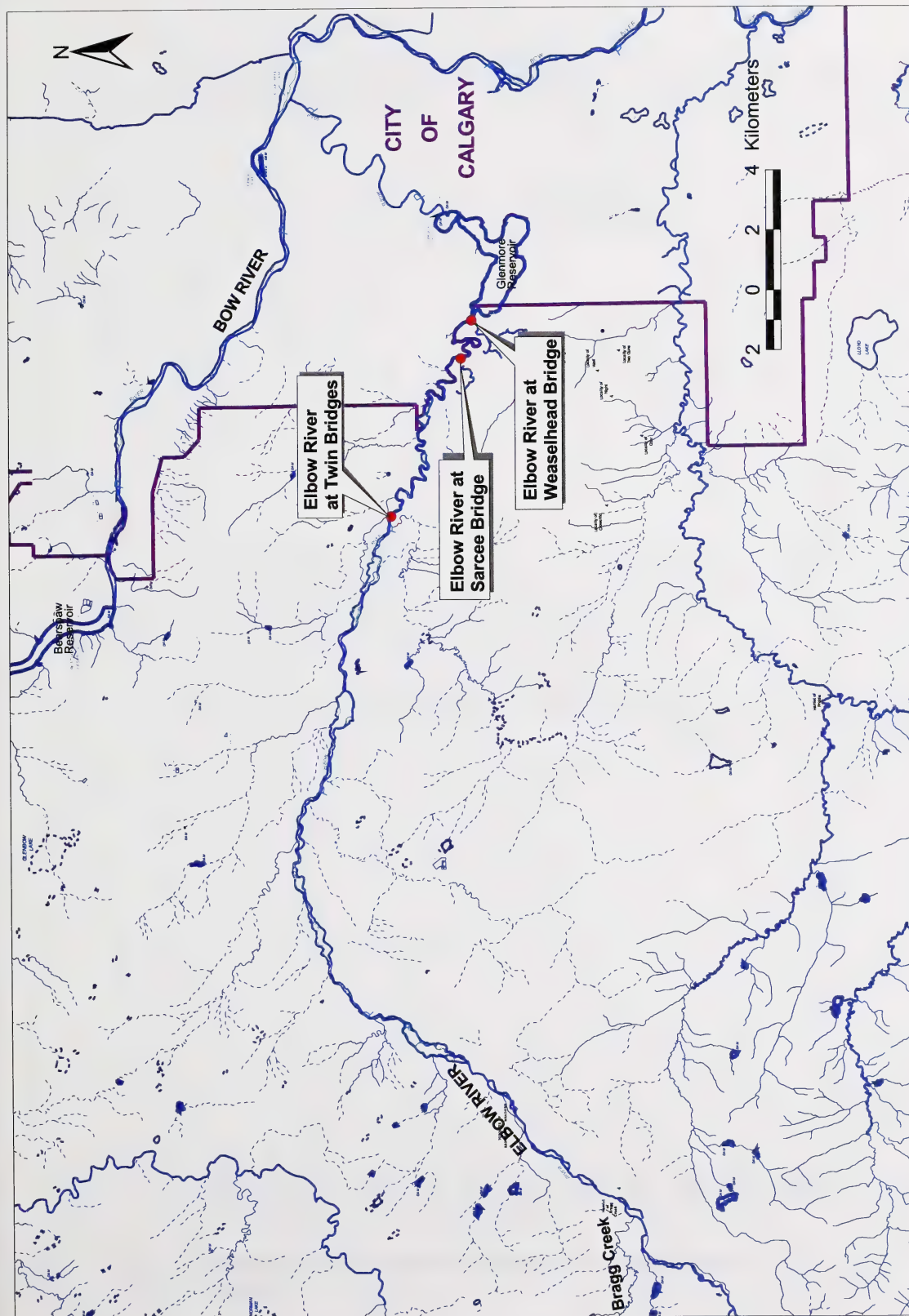


Figure 1. Elbow River water quality sampling site locations.

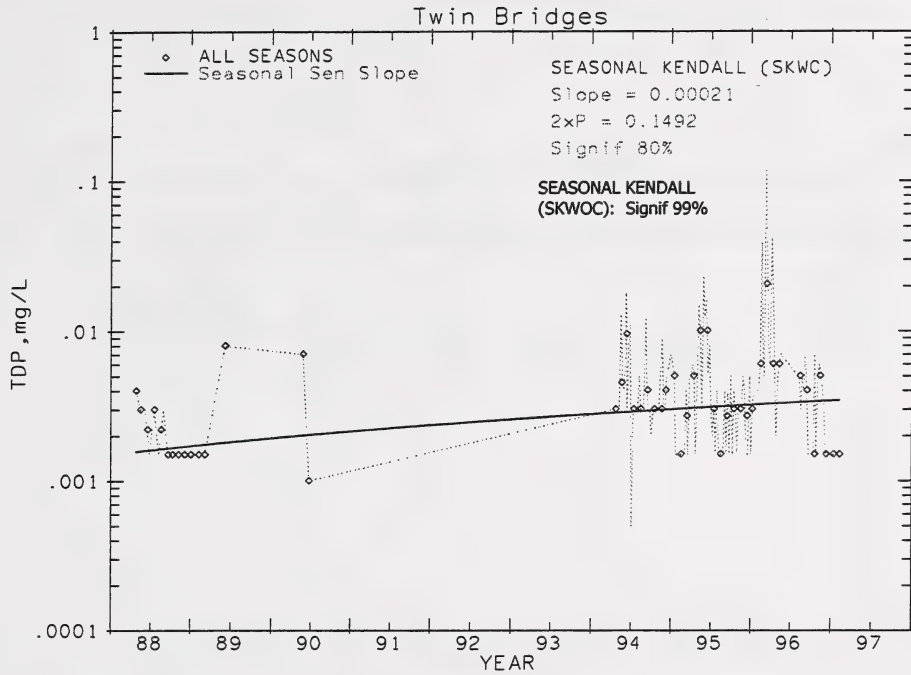


Figure 2. Dissolved phosphorus at Twin Bridges, 1988-97.

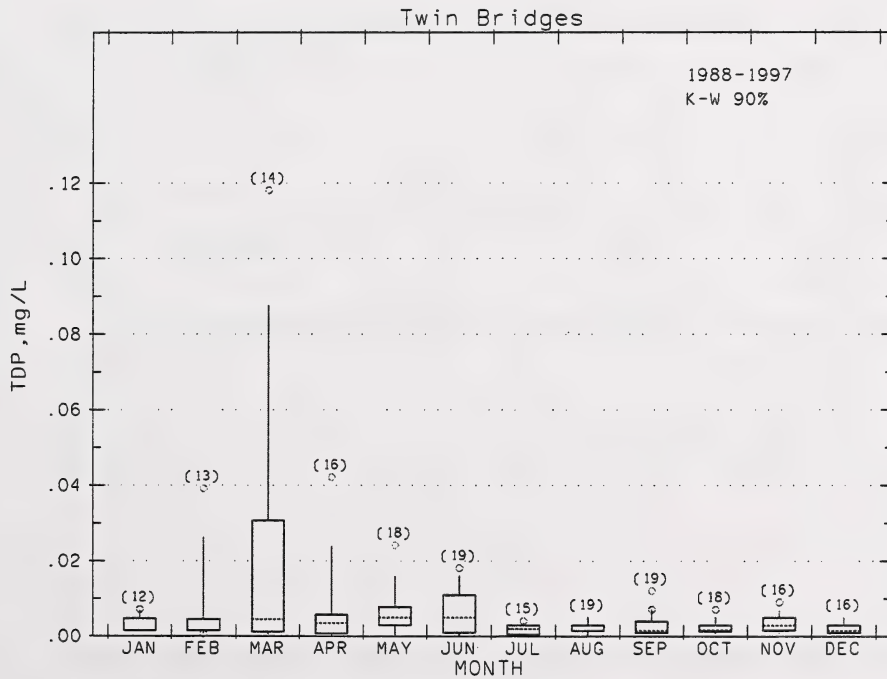


Figure 3. Seasonal variation in dissolved phosphorus. (n) = number of samples.

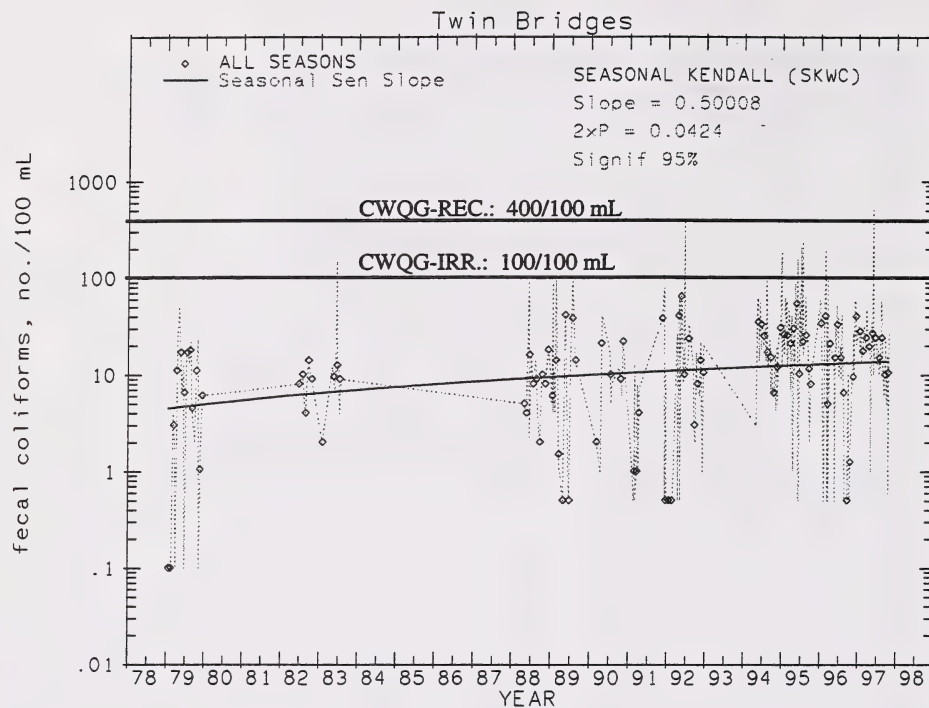


Figure 4. Fecal coliforms at Twin Bridges, 1979-97.

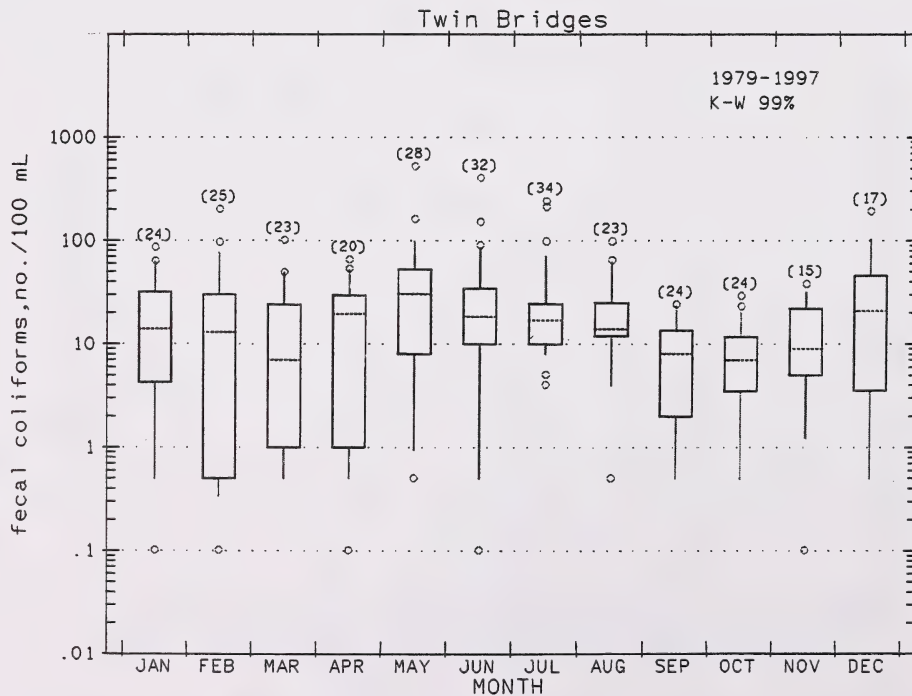


Figure 5. Seasonal variation in fecal coliforms. (n) = number of samples.

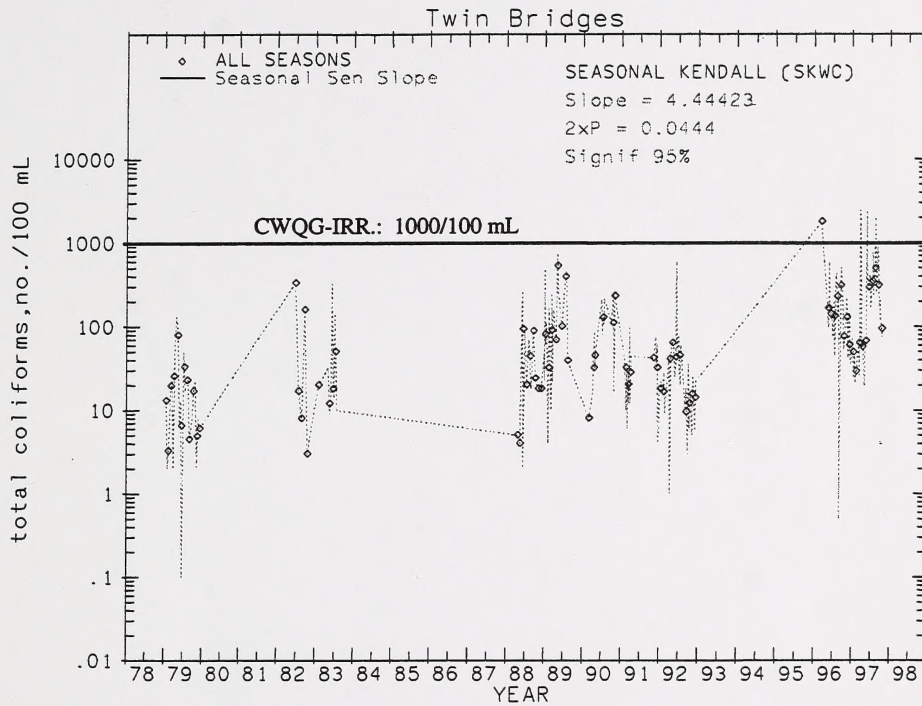


Figure 6. Total coliforms at Twin Bridges, 1979-97.

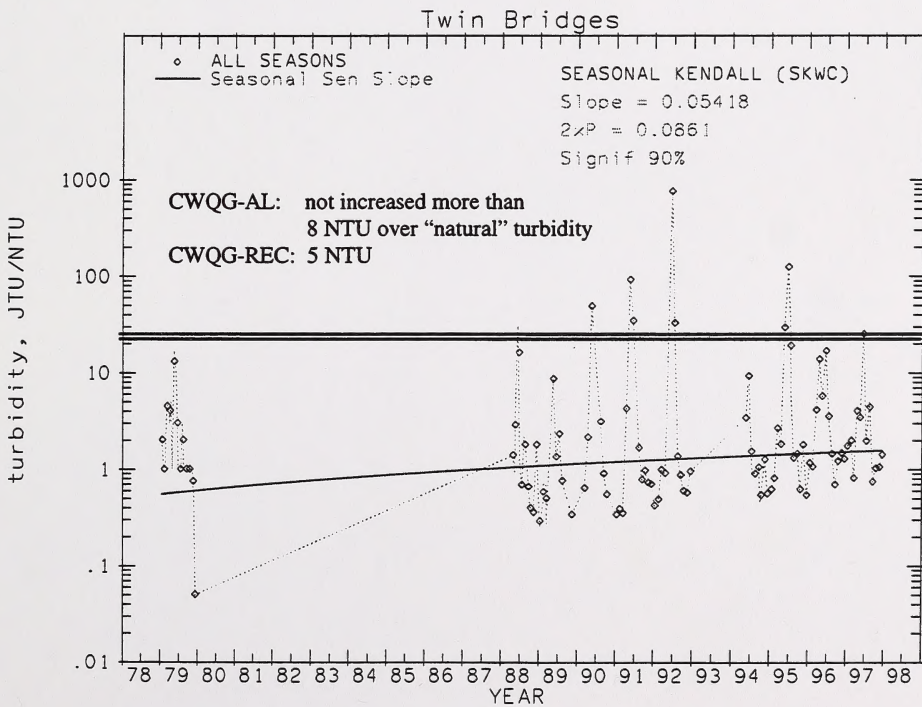


Figure 7. Turbidity at Twin Bridges, 1979-97 (JTU: 79-80; NTU: 88-97).

TABLE I	
Year	Population
1900	1,000,000
1910	1,200,000
1920	1,400,000
1930	1,600,000
1940	1,800,000
1950	2,000,000
1960	2,200,000
1970	2,400,000
1980	2,600,000
1990	2,800,000
2000	3,000,000

TABLE II	
Year	Population
1900	1,000,000
1910	1,200,000
1920	1,400,000
1930	1,600,000
1940	1,800,000
1950	2,000,000
1960	2,200,000
1970	2,400,000
1980	2,600,000
1990	2,800,000
2000	3,000,000

Source: U.S. Census Bureau, "Population of the United States, 1900-2000," Current Population Reports, Series NC-80, Washington, D.C., 1989.

